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Improvement of rail accessibility especially for eastern European countries

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Abstract

Regarding to EU regulations today's public transportation systems must be accessible for everyone without any restrictions. The relevant question is: How can trains be accessible for everyone? The huge variety of different vehicles and different platforms does not allow level boarding everywhere, only in so called "closed" systems. The paper gives an overview about the requirements for new boarding assistance systems and about the decision making process referring to a new developed lift system for UIC-coaches. This lift system is developed in the EU-founded project PubTrans4All.

Keywords: accessibility, vehicle entrance, boarding assistance device, PRM (people with reduced mobility)

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1. Introduction

The result of the previous work in the PubTrans4All-project, founded by the EU, led to the decision that the most important step towards an accessible rail system at the moment is the development of a boarding assistance system (BAS) for existing UIC wagons. These cars are still in use in large number all over Europe. Due to design limitations it is not possible to retrofit these types of vehicles in order to use existing BAS. So at the moment only platform based BAS can be used for wheel chair users. For all other types of vehicles some kind of BAS exists (lifts for high speed trains, ramps for low floor trains). The aim of further research in this project was to develop a BAS that can be used for installation in UIC wagons.

The layout of older UIC coaches and modern high speed trains that are designed for wheelchair users and other PRMs (people with reduces mobility) in general is similar. UIC coaches has small doors with a width of 800, while in modern trains the door width is increased to 900mm. The difference is that there are already lift solutions for a door width of 900mm but none for narrower doors. The UIC coach has doors located at the end of the coaches. Because of the folding or sliding steps as vicinity of the buffers as well as other constraints, there is no space under the steps for the installation of a BAS. Additionally, the space at the coach end is occupied by mechanisms of the head doors leading to the next coach, fire fighting equipment, some electrical components etc. Typical for these coaches is that the passageway is in majority cases at one side outside the longitudinal centre line of the vehicle because of the neighbouring toilet cabins adapted for people with handicaps and persons with reduced mobility. Finally, there are usually only two potential positions left which could be used for stowing the BAS.

2. General requirements for a new boarding assistance system

The general requirements provide an overview of all relevant parameters that must be considered when designing a new boarding assistance system. Table 1 summarizes the requirements (1-very important, 2-important, 3-less important). Features rated as not important, are not shown herein. The criteria catalogue was carried out in workshops and in expert talks together with representatives of different handicapped associations. Additionally 14'000 train passengers in 10 different European countries were asked during their trips about their problems and needs referring to the boarding process and about their expectation for technical devices. The answers of the passengers together with the opinion of the above mentioned persons built the basis of the criteria.

Table 1 BAS evaluation criteria - overview

User with devices	Wheelchair, walking frame, baby prams	1-2
Physical impaired	Walking disabled, with crutch or sticks, elderly, diminutive people	2
User with special needs	Visual and hearing impaired	2-3
General passengers	Passengers with luggage, children, pregnant	2-3
Operation without staff	Operation by passengers themselves, automation	2
Reliability of BAS	Prevention of Malfunction	1
Operational quality	Short dwell time, malfunctions must not influence train operations	1-2
Operational effort	Number of staff	1-2
Failure management	Problems easy to solve	1
Universalism	The system needs to be universal, retro-fitting allowed	1-2
Costs	Costs as low as possible	1
Manufacturing effort	The manufacturing effort needs to be low – especially when retro-fitting	1-2
Safety risks	No safety risks to be tolerated	1
Safety features	Optical and audio signals	1-2
Maintenance effort	Number of personnel required, special tool required	1
Costs		2
Sustainability	Recyclability and energy consumption	3
Optical design	Aesthetics is important for customer acceptance	2-3
All regulations must be fulfilled (currently according to TSI-PRM) as a minimum standard. Some specifications in project PT4All have been set higher than required.		

3. Decision making process

At the beginning of the project the consortium consciously set the bar very high in order to get the best possible results. The primary defined goal of the project was to find a technical solution to provide accessibility to all passengers in all boarding situations. To get innovative and completely new ideas, in a very first step a student competition was also initiated. The consortium believed that students don't have the detailed knowledge about railway vehicles and they are therefore more independent in their thoughts. Experts usually have a tunnel vision because they think too much about reasons why something cannot work. There were a lot of creative ideas generated by the students for technical and non technical solutions as well. One example was to use rams which can be folded out from the car body. But at the end of all technical analyses the technical requirements and frame work conditions were "too strong" why no way was found to realize one of these ideas. Nevertheless parts of the best ideas were taken into consideration for further development.

After a long research and discussion process including the excellent ideas from the competition, the consortium concluded that many restrictions are necessary and the all-in-one solution is not possible. At this point it must not be forgotten that the PubTrans4All project is a research project which also has the goal of demonstrating what is and is not possible.

In the first step, current and future plans of the different railway systems over the whole of Europe have been analyzed in order to identify the biggest gaps. For all local systems (including busses, tramways, metros, urban and suburban railway traffic) a newly developed BAS is neither necessary nor meaningful. All these systems can be seen as so called "closed systems". Here the operators provide vehicles which correspond to the existing platform height; which means level boarding is provided. If level boarding is not yet provided, then operators plan to adapt the platforms and/or their vehicles. Local traffic operators in general don't want to use technical devices (BAS) because of operational time reasons.

Level boarding is in general the best solution for travelers and for operators. It is the only situation which really offers accessibility to all passengers. Furthermore, the passenger flow in the station can be speeded up which means a shorter dwell time and therefore advantages for operators.

To offer level boarding it is necessary that the platform and the vehicle floor have a common height and the remaining horizontal gap between vehicle and platform is bridged. For that many technical solutions already exist.

For all situations where level boarding is not possible, different approved technical solutions such as ramps or lifts already exist. Compared to the local traffic systems; high speed, long distance and international railway traffic will not be able to offer level boarding for the following two reasons: The first reason is that because of static, high speed trains need a higher floor. The lowest floor height in high speed trains is offered in Talgo-trains (760mm). All other vehicles have got higher floor height.

The second reason is that in the TSI two different platform heights are defined as European standard (550mm and 760mm). That also means for the next decades all international trains will need to stop at both levels!

Furthermore, the investigation has also shown that actually within the next decades a huge number of high floor vehicles will run in European countries in long distance traffic. Due to the long life cycle of railway vehicles they can't be changed in a short or medium term.

So the decision was to develop a BAS for all types of high floor vehicles. In general there are four possibilities – ramps or lifts, platform or vehicle based. The operators' surveys clearly show that operators either plan to provide level boarding in the future or – everywhere they cannot – they strongly wish to have vehicle based systems. Two reasons can be identified for that wish: Firstly, operators want to be independent from the infrastructure and want to offer the possibility of accessible boarding everywhere. Secondly, it is very difficult to provide a platform based device at all (!) platforms in a railway network.

In order to provide accessibility to all passengers, ramps seem to be the only possibility because lifts cause a big bottle neck if every passenger tries to use one door. But here the big problem is that it was not possible to find a technical solution for installing a ramp system into existing vehicles. Furthermore, ramps must be very long if they will be used for high floor vehicles.

Because of the impossibility of finding any technical solution for ramps in existing high floor vehicles, the decision was to focus on lift systems for existing high floor vehicles. For the next steps of development two decisions have been necessary: Who the user will be and which vehicles are relevant.

The investigations show that for all types of high floor trains with an entrance door width of at least 90cm, different lift systems already exist. It is not meaningful to develop another system because passenger and operator surveys have shown that the existing systems work well enough.

But there is one very big group of high floor railway vehicles in Europe, the so called UIC-wagons. This is a unique type of vehicle which will be running in many European countries for some decades more. In many countries the UIC-wagons form the backbone of the long distance railway traffic, especially in eastern European countries. But due to many construction limitations described in previous deliverables no technical solution has yet been developed. Therefore, the consortium came to the decision that the most important step to offer accessibility to all is to focus on UIC-coaches!

A lift system under very limited frame condition means many restrictions and compromises. In regard to user requirements, wheelchair users are the only passengers for whom a technical solution is an absolute must. For many other groups it would be very nice to have some technical devices; but if there is no chance, than other solutions are acceptable. As other solutions, special services at the entrance door are recommended within this project. There already exist good examples in different European countries which can be advanced.

At the end of the decision process, it came out that the most important case is to develop a vehicle based BAS for UIC-coaches. Since there are many restrictions because of the vehicle design, it has also for this situation been necessary to define some "compromise solutions" regarding the construction. All recommendations for a vehicle based BAS for UIC-coaches are shown in the next chapter "Detailed technical requirements for a BAS for UIC wagons".

4. Technical requirements for a BAS for UIC wagons

As described in the chapter "decision making process" the consortium decided to focus on a BAS that can be implemented into UIC wagons. Therefore, at this point all technical requirements that have been identified especially for the implementation into UIC wagons will be described in detail.

Table 2 Applicability of a BAS in different vehicles

Characteristic	Value	Comment
Carrying capacity	300kg	Covers 99% of wheelchair users
Minimum clear width of lift platform	720mm	Covers 96% of wheelchair users
Minimum platform length	1200mm	
Maximum working height difference vehicle floor-platform	1300mm	
Distance from the side of the coach when the lift platform is in lowered position:	as small as possible, but not less than 75 mm	The lowest foldable stair required to be lifted up before descending of the lift platform.
Boarding/alighting parallel to the vehicle	recommended	Alternatively, exit sideways through lay down of the side fenders (required for narrow platforms)
Handrail bound to the platform on one side, should be at the height of	650 to 1100mm from platform level	
Integrated folding seat for categories of users other than wheelchair users	recommended	
Finger pressure for activation of control buttons	≤ 5N	
Manual force to operate the lift by staff	≤ 200N	For example for emergency mechanical activation.
Manual force to operate the lift by staff at movement start	≤ 250N	Allowed only for short period at the start. For example for emergency mechanical activation.
Vertical speed in the operation	≤ 0.15 m/s	Movement should be smooth
Operating speed variation: empty-maximum loaded	±10%	
Speed of any point of BAS without load	≤ 0.2 m/s	Up to 0,6m/s is allowed by EN 1756-2. To meet TSI PRM, maximum speed without load no more than 0,3m/s is recommended.
Acceleration during operation with load in any direction and at any point of the lift platform	≤0.3 g	
Tilting speed of the lift platform	≤ 4o/s	In case of automatic adaptation to the relative angle between vehicle and platform, for example at superelevated track by platforms in curves.
Automatic roll-off protection height	≥100mm	The barrier in front and at rear side of the wheelchair lift platform should be automatically erected during lift operation.
Lateral side guards height:	≥25mm min ≥50mm preferred	Prevention of the wheelchair side roll-off from the lift platform
End of travel mechanical limitation devices	yes	
Prevention of any unauthorized operation in	yes	Locking and unlocking by a key or a code or

the absence of the operator		similar.
Overload protection of the main power electrical circuit		Fuse, an overload cut-out or similar
In stowed position BAS must be safe against uncontrolled displacements. Mechanical securing devices dimensioning according to the accelerations:	alongitudinal=5g alateral=1.5g avertical=1g	These accelerations can arise in the exceptional case of occasionally buffing impact at coach staying in yard (without passenger) (UIC 566)
Activation possible only at:	V = 0 km/h.	
Activation of the BAS should introduce activation of the coach brake system.	yes	Movement of the train during BAS usage must be prevented
Minimum safety coefficient against yield strength	2.1	
The lift platform surface should be smooth and must have slip-resistant surface	yes	Slip resistance according to EN ISO 14122-2.
Easy removal of ice and snow must be possible	yes	
Gaps or holes in the platform area shall not accept a probe greater than:	15 mm diameter	
Illumination of the lift working zone	yes	
The warning devices should be fitted at edges that can come in contact with persons or injure passengers or personal.	yes	light / reflective stripes / reflective markings, visible at night also
Visual and audible warning signals during the lift movement must be activated	yes	
The operation control should be of type hold-to-run.	yes	Lift shall stop moving and remain motionless after the control is released.
Movement no more than 100mm for any part of the lift platform after release of the control is tolerable to slow lift down	yes	Mechanical drives with self-braking capability or with independent direct acting brakes, or hydraulic systems with normally closed valves etc. should be used.
Controls shall be designed to avoid unintentional lift actions.	yes	Recessed or covered buttons, two hand controls, etc.
One control position is recommended	yes	Conflicts of commands must be avoided
In any case of breakdown, it is acceptable that platform may decrease with controlled speed:	≤ 0,165 m / s	For example in hose or pipe failure by hydraulic systems or similar.
Safety devices shall preferably operate through active positive action.	yes	
A stop in overload protection should be present at overload more than	25%	
An emergency stop button within reach of the user should be present	yes	Release of the emergency stop button should only be possible by the personnel
Additional protecting measures such as obstacle detector, foot entrapment protection etc.	recommended	Although control of hold-to-run principle is used additional measures are recommended
During lift platform closing the risks of crushing or shearing of the arms or head must be avoided.	yes	Limitation of the closing force, security cut-off, etc.
Other technical details not covered in this table preferably should be based on:	TSI PRM, EN 1756-2, RVAR	

5. Lift development

The UIC wagon shall be equipped with a total of two BAS in future. These are located on both sides in the wagon with an universal WC and wheelchair spaces. Due to the given space in the entrance area different lift models have to be taken into consideration e.g. regarding the storage and handling. The positioning of the lifts has been reviewed in detail and has been tested with a prototype with 270° swiveling.

5.1. Technical details

The prototype has a load-carrying capacity of 350 kg maximum and a lifting height approx. 1000 mm (1150 mm max.). The lifting speed is ≤ 0.15 m/s (with max. load-carrying capacity), the lowering speed is ≤ 0.15 m/s (with max. load-carrying capacity). The lift total platform width is 800 mm. In the parking position the lift have a width of 1045 mm, a depth of 259,5 mm and a height of 1633 mm

5.2. Supporting structure

The frame is implemented in the form of a strong-dimensioned steel construction composed of welded right-angled hollow sections. The top and bottom of the rotary column each have one bearing pin for seating the structurally identical swivel bearings. These sit in fittings with which the Trainlift is screwed into the vehicle. In the lower bearing flange there sits the lock for the swung-in parked position and the operating position swung out 180°/270°. The lifting column guide constitutes the other side of the supporting structure. At the bottom there are sturdy, adjustable pulleys for guiding the lifting column mounted inside. The lifting column is implemented in the form of a right-angled hollow profile and slides down in the guide pulleys of the lifting column guide and up in two maintenance-free pulleys mounted in the lifting column. At the bottom, the lifting column carries the lift platform via a hinge. The lifting column moves via a hydraulic drawing cylinder located inside.

5.3. Complete lift platform

The lift platform consists of the platform centrepiece, the roll-on ramp with automatic rollstop and the ramp for bridging passage into the vehicle. The bridging ramp and roll-on ramp can be folded over onto the lift platform. In this position the lift platform can be completely folded up for stowing away and vertically locked in place. Here, a pneumatic spring counteracts to a great extent the weight of the platform. The side barriers can be laid down respectively taken off the platform in case of spacial restrictions, in order to allow the sideward boarding in case of narrow station platforms.

5.4. Hydraulic system

The hydraulic power unit is implemented in the form of a fully integrated unit with oil storage tank, gear pump, directional control valve, pressure control valve, measuring connection, oil level monitor, air filter and manual pump for emergency use.
Propulsion of the lift is carried out via a hydraulic draw cylinder with a shut-off valve directly on the cylinder for pipe breakage protection. Hydraulic power unit and lifting cylinder are connected to each other via a pipeline.

5.5. Electrical system

Electric motor and controls are fed through the on-board vehicle power supply network via a terminal strip on the Trainlift. A sufficiently long connection cable and a connection plug for the vehicle-side connection are provided by the vehicle's manufacturer. The electrical system consists of the switch box with terminal strips and motor control contactors, control voltage supply, four position switches and one key-operated push button. One position switch indicates that the rotary column is locked in the swung-out position for operation (rotary column locked). The second position switch indicates the position: lift platform folded out. The switches are connected in series. Both signals are necessary so that the electric motor of the hydraulic power unit can be connected. The third position switch indicates that the Trainlift is swung-in in the parked position. The fourth position switch shorts the security switch and puts the lift out of operation.

5.6. Safety features

The BAS is equipped with the safety features. Lifting and lowering are possible only when the Trainlift is swung out and locked in place and the lift platform is laid down. In the case of obstacles for the lowering motion, the Trainlift remains still because lowering is accomplished only by gravity with support from a pneumatic spring. The foldable roll-on ramp has automatic roll-away protection (rollstop) against the wheelchair user rolling off. The entire surface of the lift platform and of the ramps has a slip-resistant construction (slip-resistance class: R13). Lifting of excessively heavy loads (beyond 350 kg) is prevented by a pressure control valve. The pressure control valve restricts the force when approaching the upper fixed stop during lifting motion. The shut-off valve directly on the lifting cylinder prevents the lift platform from plummeting in the event of a hydraulic pipe rupture. Yellow warning marker encompassing the lift platform, ramps and rollstop. For the safety of the wheelchair user there is a handle at the side on the lifting column guide.

5.7. Unlocking the lift from rest position

The locks on the pivoting casing panel have to unlocked and swing the casing panel toward the main casing.Unlock lock. The inset handle is released by the lock. Upon swinging open the handle, the floor latch is opened via a linkage. The lift is then free to swing out.

5.8. Closing and opening the lift platform

The lift platform is folded up against and locked onto the lifting column in rest position. After unlocking, the lift platform is manually folded out. The handle must be used. In the hinge section of the lift platform there is pneumatic spring that counteracts to a great extent the weight of the lift platform while swinging.
After folding the lift platform back up, it automatically locks back up in the vertical position.

5.9. Lifting and lowering the lift platform

The electric motor of the hydraulic power unit can be controlled with the key-operated push button only when the BAS is swung out in operating position, the lift platform folded out and the signal for retracting the foot step given. The hydraulic power unit presses oil into the lower piston annulus of the cylinder: The piston with piston rod is lifted and lifts the platform hanging on it.

The shut-off valve on the lifting cylinder and the return valve are electrically opened via a key-operated push button. Via a flow-control valve (valve for controlling the lowering brake) the oil can flow back from the lifting cylinder to the storage tank. A pneumatic spring supports the lowering motion. This ensures that the lowering speed for an unloaden lift platform is sufficiently high.

5.10. Installation Case Study / Collisions

Based on the drawing the following installation case study was made and presented during the last two PDG meetings. Further investigations showed that there are collisions in the entrance area of the wagon.

There are collisions with the handrail and the cover of the end wall. One solution will be “an embedded handrail instead of an outside handrail should be provided” by BDZ. In addition the wall has to be adapted. There are two additional collision areas, the door locking system of the entrance door and the guide rails of the passing door, which are on the floor and not embedded. Additional vehicle drawings are necessary for further investigations. New requirements for the cover of the lift as it has to be adapted to the window shape. Finally, the investigation study showed that the swivel step must be decoupled from the door impulse. The collision is not only the swivel step itself but the vertical connection rod to the wheel step. The collisions are with the fixing support and rotary column of the lift. The decoupling of the swivel step from the door impulse is necessary to have the BAS installed properly and to ensure a perfect operation of the lift.

6. Functional description

6.1. Putting into operation

Unlock the three sash locks and swing the casing panel around toward the main casing. Lock the open casing panel in place. Open up the lock in the inset handle. Unlock using the inset handle, the BAS is ready to swing out. From the platform, the lift platform (snap lock) has to be unlocked and laid down into operational position. The handle must be used. If the vehicle has a retractable foot step, it must now retract automatically. The bridging ramp to the vehicle is placed vertically. Locking into place is accomplished via the guide linkage and spring lock. The BAS is positioned in the upper operating position.

6.2. Entering the vehicle

The BAS is swung out and ready in the upper operating position. The service personnel is standing on the train platform. The bridging ramp must be locked in the 90°-position. Locking in place is accomplished via guide linkage and spring lock. Afterwards the "Lower" key-operated push button has to be actuated counter-clockwise until the lift is set down on the platform. During lifting, the operational personnel must keep the wheelchair user under constant observation. The wheelchair user leaves the Trainlift.

6.3. Return to the parked position

The Trainlift is standing ready, swung out in the lower operating position on the train platform. The operational personnel is likewise standing on the platform. Actuate the "Lift" key-operated push button (clockwise) until the lift platform reaches its upper stop. Fold in bridging ramp and lay onto lift platform. Fold in lift platform extension and lay onto bridging ramp. Fold up lift platform using the handle and audibly lock in the snap lock. Unlock BAS with unlock lever. Swing the BAS back inside the vehicle until it audibly snaps locked in place. Lock the lock in the inset handle and remove key. Swing casing panel all the way back in and lock the three sash locks starting from the top.

6.4. Emergency use

In the case of loss of the electrical power or failure of the hydraulic power unit during operation with a wheelchair user on the lift platform, the lift can be manually lowered.

Close both shut-off valves again. Take the extension piece for the manual pump lever from the mounting beneath the crossbeam and insert it. Move the manual pump lever back and forth, the lift platform rises. Raising the lift platform from the level of the platform to the upper stop requires approximately 200 pump strokes. The lift platform has to be pumped up to the upper stop.

7. Testing

The testing of a new boarding device, which will allow barrier-free adaptation of existing UIC wagons are to consider in addition to testing a mock-up only in real mode on the future operating conditions.

The rolling stock were built in the last decades and partly renewed, so the installation of a new system has to be checked. The production of a mock-up of that car segment according to the plans and dimensions of nature was therefore an important step to test even the installation of BAS and the necessary adaptations to the vehicle. The mock-up tests were also important for testing the space for the action area of the BAS and a passenger with a wheelchair. It was also carried out a real operation of the BAS in the Bulgarian railway network and used the built-in BAS successfully on its serviceability at several stations with different platforms and track characteristics.

7.1. Evaluation of the mock-up tests

The boarding device is adapted from a BAS that is used worldwide as a standard product in many features of MBB. For installation in the UIC wagon the BAS had to be adjusted are to meet the limited needs for space in its external dimensions. Thus, the design strength of the initial aid was reduced in the stowed position to the required aisle widths inside the car needs. Furthermore, the swivel range of the BAS had to be increased to 270 ° to allow an installation in order to access aid in the side wall along the direction of travel.

The installation of the adapted lift was simulated in drawings before the installation in the mock-up. To test the space and usability of the system and the installation a mock-up was constructed, which according to plans and natural dimensions of the used UIC-waggon.

Fig 1.: BAS in the stored position installed in a UIC-vehicle (from BDZ - Bulgaria)

The test of the BAS in the mock-up was successful and showed that the boarding device is suitable for use in an existing UIC wagon. The tests at the mock-up were reviewed and the required measurements performed a test with a maximum load of 300 kg. The evaluation of the tests showed that the use of boarding device should only be performed by trained personnel in order to avoid the danger of pinching when folding the boarding aid. Another point for improvement of the system under test is the existing system for emergency operation. The emergency operation is only for use to store the initial help from a loss of hydraulic system in order to be able to handle the train. Due to the arrangement of the emergency but it is difficult to operate. To test the effects in real operation of the platform and the track characteristics and the BAS was fitted in UIC wagon.

7.2. Evaluation of the installment in the UIC-wagon

The installation of the initial aid in the existing UIC coaches was made by the workshop of the Bulgarian State Railways. The wagon has been adapted before installation in the field of the entry. The inner lining of the front wall had to be moved outside to get sufficient space for the turning radius of the initial aid. For the necessary transition width in the transition area the wall was moved to the toilet too. To fasten the BAS in the area of the door opening, a mounting point has to be retrofitted and in the region of the side wall reinforcements are carried out. To obtain sufficient space for the construction of the lift and the necessary turning radius, in this sensitive area, several modifications were made to the design. The current drive of the folding step has been completely replaced by a new drive system and the existing wiring had to be transferred.

Fig 2.: Assembly point for the BAS

The adaptation of the wagon works were carried out in a maintenance work, which is normally not equipped for such works. The evaluation has shown that the preparatory work for the subsequent installation of a boarding device is extensive and as a result of the interference with an existing structure due to a variety of professionals.

7.3. Evaluation of the real life testing

The prototype was tested in the Bulgarian railway network in real operation. The wagon in which the boarding device is installed, was used on a main route from Sofia to Pleven starting in real railway operation and the entry and exit for wheelchair users were tested with the help of the prototype. In order to test all possible starting situations the holding stations were chosen with different platform heights and different arc radii and track cants.

Fig 3.: BAS in test operation on Bulgarian rail network

To check the entry in the real system operation, two subjects which are wheelchair users were invited to be present and also to evaluate the system during a test session. The subjects are satisfied with the BAS and feel this as an useful addition to barrier-free travel by rail. From the perspective of the user, a further need exists for a fold-out handle bar, which can be folded down during the lifting operation and serves as a holding possibility for the wheelchair user. The handle bar further serves an additional mechanical barrier against rolling of the lifting platform. Furthermore, it is an optical barrier, which gives the customers, especially at low platform heights and the associated large vertical distance a greater sense of security.

The boarding is easy with a side run up and down the wheelchair from the platform to use. The test platform was tested with a minimum width of 1120 mm and a platform tilt of 6 %.The tests have shown that the boarding device can be used on flat platforms up to a platform height of 110 mm without restriction. For platforms in curves and track cant, there are problems with the tilt of the wagon, which can become a danger to wheelchair users. The boarding aid has been successful tested to a vehicle inclination of 10% but because of security without a person.

From the perspective of the operator the operation of theBAS is easy to handle and user friendly. Improvement is seen in the fixation of the initial aid in the unfolded position, as these can be solved relatively difficult for folding. Another suggestion is the use of the controlpanel. This is connected with a cable to the BAS and mounting height requires a result of embracing the customer. The costs for retrofitting the car with the BAS have not yet been collected. The cost of the lift is amount to € 35,000, the cost of adapting the car and all other costs for planning and licensing are not yet known.

8. Conlusions

Providing accessible rail transport to all passengers is nowadays a must. This is because of different national and European regulations but also because of ethical questions. That means every person must be able to use a public means of transportation. In light of this, the entrance to railway vehicles and the whole boarding process is a big challenge and causes huge difficulties. In order to be able to provide accessible boarding to all passengers, the consortium tried to define the biggest gaps that must be closed.

For mid and long term thinking the results can be summarized as follows: Because level boarding is in the process of being or will be offered soon for all types of local, urban and suburban traffic; no systems are required. At this point, only horizontal gaps need to be bridged. Therefore, enough technical solutions already exist. In the rare case that level boarding is not possible, existing technical solutions can be used. For all high floor vehicles with an entrance door width of at least 90cm, enough technical solutions such as different lifts exist. A new development is neither meaningful nor necessary.

The intensive investigations of the consortium led to the result that for the huge number of UIC-wagons which are running and will be running within the next decades all over Europe no vehicle based BAS yet exists. There are too many design limitations. Due to the fact that UIC-wagons will still form the backbone in many European railway networks within the next decades; it is absolutely necessary to develop a BAS for this operation.

Due to the different limitations resulting from the vehicle construction, it is also necessary to make several compromises. But the developed compromise allows about 99% of all actual wheel chair users to board a UIC-coach. In combination with a good personnel service at the entrance, which is also recommended in this project, the UIC wagons can also become accessible for nearly all passengers.

The evaluation of the comprehensive test of the initial aid operations in the Bulgarian railway network has shown that existing UIC coaches can be retrofitted with the appropriate adaptations to the accessibility requirements. The prototype of the BAS is stated all requirements and also allows to perform in adverse situations such as low platform heights or platforms in sheets with elevation.

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